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National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No. NAS-5-3760

ST — LPS — 10 242

NASA TT F-8992

ON THE PRESENCE OF OXYGEN IN THE ATMOSPHERE OF VENUS

by

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[USSR]

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FACILITY FORM 602

N65 11443 (ACCESSION NUMBER)	(THRU)
8 (PAGES)	1 (CODE)
(NASA CR OR TMX OR AD NUMBER)	30 (CATEGORY)

17 NOVEMBER 1964

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ON THE PRESENCE OF OXYGEN IN THE ATMOSPHERE OF VENUS

Izv.Krymskoy Astrofiz.Observ.
Tom 31, 276 — 280,
Izdatel'stvo "NAUKA", 1964.

By V. K. Prokof'yev

SUMMARY

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Spectra of solar light reflected by Venus at 1 Å/mm dispersion in the 6300 Å region (α— oxygen band) have been obtained during the period May — July 1962. With the approach of Venus to the Earth a weak absorption band was detected on the shortwave side of the telluric oxygen band. This band may be due to the presence of a negligible amount of oxygen in the upper atmosphere layers of Venus. Author

* * *

As Venus drifted away from the Earth in August-October 1961, spectra of solar light reflected by Venus were obtained during early morning observations in the telluric α-oxygen band region (λ 6300 Å) at a dispersion of 1 Å / mm [1], and studied. As a result of a careful photometric processing, the presence of weak absorption lines, situated at the longwave side of oxygen telluric lines, was established. The assumption was voiced, that these weak lines could be explained by absorption of oxygen situated in the upper layers of Venus' atmosphere. The then observed shift of the detected weak lines as a function of the variation of the relative motion velocity of Venus toward the Earth corroborated that assumption.

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However, the observation of similar weak lines from the shortwave side from telluric lines could constitute a substantial corroboration of such conclusion. To that effect, observations should be conducted during the period of Venus approaching the Earth (evening observations). Only a single spectrum responding to such conditions could be obtained in February 1961. However, it was not adequate for a careful photometric analysis and thus could not be sufficient for concluding of the presence of similar weak lines on the shortwave side of the telluric line contour.

Evening observations were pursued in May-July 1962 by means of the same spectrograph [1]. A film A-660 of experimental manufacturing was used as the photographic material. Our experiment has shown, that this film had nothing to yield to photographic plates Kodak 103 a E, on which the 1961 spectra were obtained; the only difference consists in a slightly coarser grain. Quite good spectra were obtained with this film in July 1962 with a 90-minute exposure, which were subsequently subject to a careful photometric processing. During the same period a solar spectrum was obtained with an exposure of ~ 30 sec and a height of the Sun above the horizon of $\sim 10^{\circ}$. When photographing the Sun's spectrum, the main mirror of the tower telescope was stopped down by a perforated diaphragm. Intensity marks were obtained simultaneously in the physical laboratory, using a KSA-1 spectrograph, by means of a step-by-step reducer; an incandescent lamp served as the light source, the voltage being so chosen that the duration of the exposures be equal to the duration at photographing Venus' and Sun's spectra. All films were developed simultaneously.

The same 10 lines of the P-branch of the α-oxygen band that were utilized earlier [1] have been subject to photometric analysis. However, in this case we have been meeting with serious difficulties, to which attention had already been drawn in [1]. We reproduced in Fig. 1 the combined contour of 9 telluric band lines from ref. [1], which reveals a weak absorption line on the longwave wing (positive $\Delta\lambda$). The position of this band corresponds to Doppler shift in Venus' spectrum (shown by an arrow). The position of the lines of the solar spectrum ($\odot$), taking

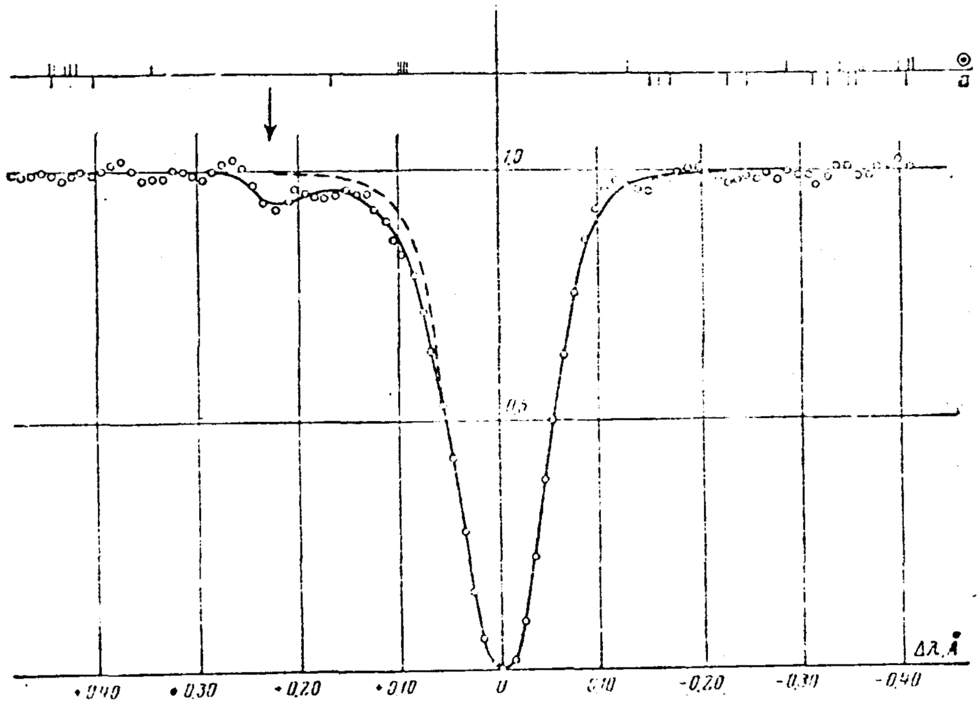

Fig. 1. - Averaged contour of telluric lines of the α- oxygen band, obtained by Venus spectrum photograph of 22 - 23 August 1961.

into account the Doppler shifts, the atmospheric bands of water vapor (a) and of oxygen isotope. As may be seen from Fig. 1, there are no interfering solar or water vapor lines on the longwave wing of the region necessary to us. Only one line of oxygen isotope O^{16}, O^{18} exists there, which is very weak (1 : 600 by intensity). A considerable accumulation of water vapor lines is noted on the shortwave side of the contour (negative Δλ) in the region Δλ from — 0.15 to — 0.40 Å. The presence of these lines constitutes precisely the main difficulty at spectrum analysis. The telluric lines, near which these bands are found, could be excluded from the analysis; however, in such case too few lines would be left for the statistical processing. The Table (next page) illustrates the disposition of the telluric lines of oxygen and water vapors from the shortwave side. This Table shows that there is not a single telluric oxygen line near which a water vapor line would not be seen within the limits to — — 0.5 Å.

It should be noted that at evening observations of Venus, the role of water vapors is somewhat more effective, than in the morning. Evening observations start after sunset, when Venus is high over the horizon. At such position, a certain amount of favorable time for the photographing of spectrum is spent on telescope setting. The photographing of the spectrum is continued to a rather low position of Venus above the horizon, when the radiation from it passes a great thickness of the Earth's atmosphere.

TABLE.

№ п/п	λ_{O_2}, Å	λ_{H_2O}, Å	$\Delta\lambda = \lambda_{H_2O} - \lambda_{O_2}$, Å
1	6306,575	6306,414; 6306,225	—0,161; —0,350
2	6305,819	6305,321	—0,498
3	6299,231	6298,800	—0,431
4	6298,462	6298,309	—0,153
5	6295,986	6295,657	—0,309
6	6295,186	6294,672	—0,514
7	6292,967	6292,622	—0,345
8	6292,170	6291,931; 6291,775	—0,240; —0,400
9	6290,224	6289,903	—0,321
10	6289,403	6289,181	—0,222

During morning observations, the low position of Venus above the horizon is used for telescope setting; photographing begins when Venus rises to 8 — 10° above the horizon, and is pursued through sunrise, i. e. at morning observations the effective thickness of the Earth's atmosphere is substantially less than in the evening.

Taking all this into account, it was decided to exclude from analysis only those portions of the spectrum, where blending of separate wings of the telluric oxygen lines is clearly seen on the registrograms.

The photometric analysis was conducted here, as described in [1]. As a result of superimposition of separate telluric line contours, an average contour was obtained, which was then subject to further analysis.

Such an averaged contour, obtained by the solar spectrum, is plotted in Fig. 2. Above it, the disposition of solar lines (☉) and of water vapor lines (a) is shown. As should have been expected, this contour was found to be very symmetric. In order to outline

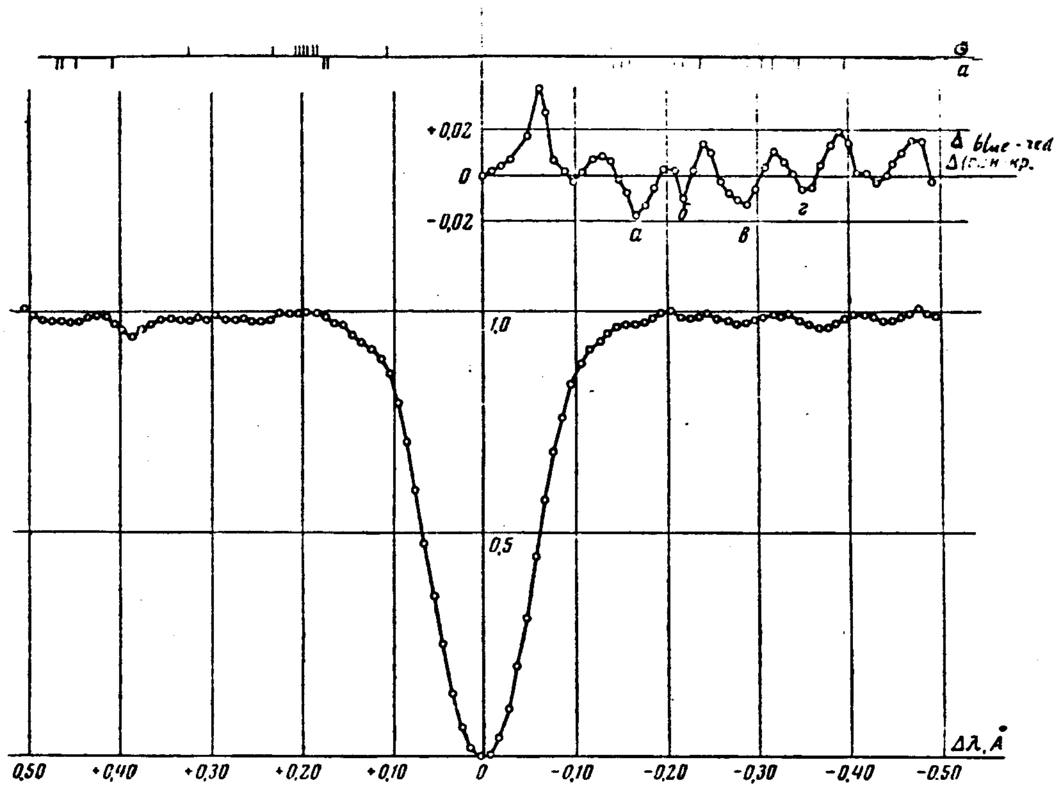

Fig. 2. - Averaged contour of telluric lines of the α -oxygen band obtained by the Sun's spectrum

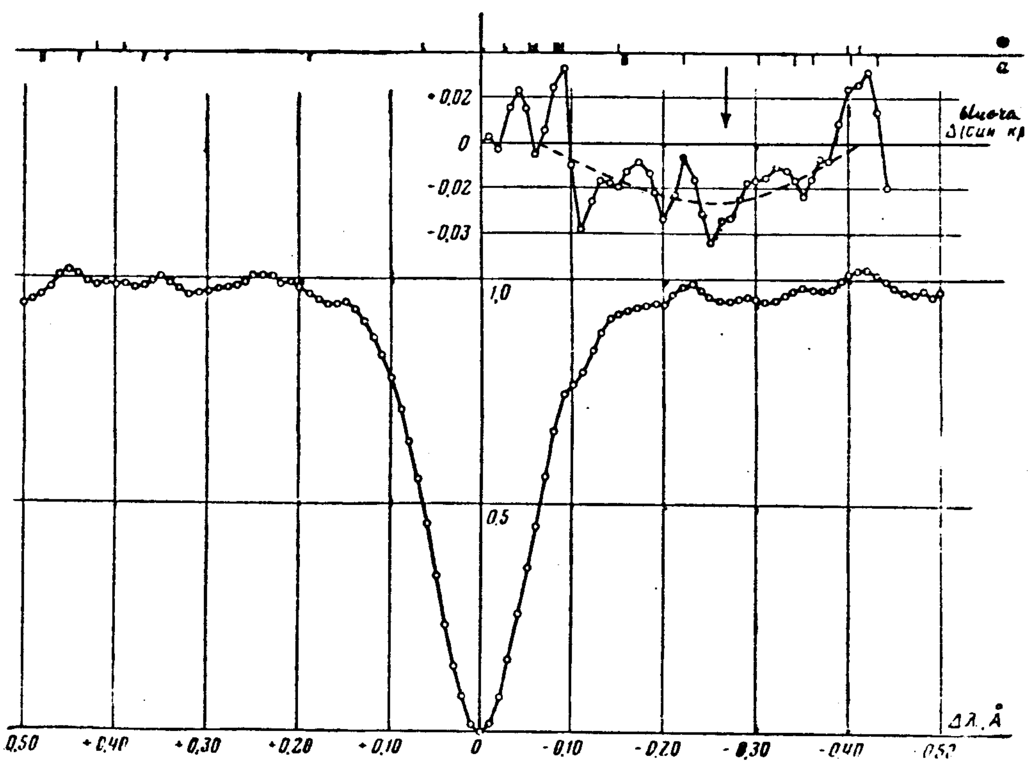

Fig. 3. - Averaged spectrum of telluric lines of the α - oxygen band obtained by photographs of Venus's spectrum on 5, 6 and 27 July 1962.

the role of water vapor absorption lines, we plotted the differences of the points of the blue (shortwave) and red (longwave) wings of the contour — Δ(blue-red). The scale of the difference was magnified X5 by comparison with that of the contour for better demosntration. The course of the differences reveals a certain influence of water vapor absorption lines (points a, δ, ε, ι). On the whole, however, the points are distributed on both sides of the zero line.

The average contour of telluric oxygen lines in Venus' spectra obtained on 5, 6 and 27 July 1962 at the respective Dopller shift of 0.26 A (5 and 6) and 0.27 Å, is plotted in Fig. 3. We marked above the position of solar lines, taking into account the Doppler shift (⊙), and that of the atmospheric ones (a). The contour is also sufficiently symmetric; however, it discloses a certain depression in the shortwave wing, which is particularly well visible on the difference curve Δ(blue-red) shown in the same Figure, the scale being increase fivefold along the ordinates. As may be seen, the curve of differences Δ is systematically running below the zero line over the portion —0.10 Å → 0.40 Å, which is particularly noticeable by comparison with the similar curve in Fig. 2. If in the latter the points of the curve are distributed near the zero line, then in the case of the Venus' spectrum, the curve is systematically shifted downward. This displacement is partly due to the presence in the spectrum of Venus of telluric lines of water vapor absorption. (a, δ, ε, ι in Fig. 2).

As follows from Fig. 2. the indicated water vapor absorption lines cannot, however, wholly explain the observed shift of the difference curves, and the more so, since the maximum of this shift is situated at a distance of ~ — 0.26 Å, corresponding to Doppler shift in Venus' spectrum (indicated by an arrow in Fig. 3).

Thus, we reach the conclusion, that even in this case, the presence of a weak absorption line caused by the presence of negligible amounts of oxygen in the upper layers of Venus' atmosphere, is revealed from the shortwave side of telluric oxygen lines' contour when Venus drifts nearer the Earth.

*** THE END ***

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CONTRACT No. NAS-5-3760
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Translated by ANDRE L. BRICHANT
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